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SOVIET CONFERENCES ON ELECTRONICS

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SOVIET CONFERENCES ON ELECTRONICS

Fourth Scientific Technical Conference on Nuclear Radioelectronics

[This is a translation of an article written by A. A. Sanin in Pribory i tekhnika eksperimenta (Instruments and Experimental Techniques), No 4, 1959, pages 161-163.]

The conference on Nuclear Radio Electronics was held in Moscow from 20 through 25 April of this year. This conference is of great significance to the further expansion of the use of nuclear radio electronics in the national economy of the country and science.

Participating in the conference were approximately 1000 persons. More than 100 papers and communications on various problems of nuclear radioelectronics were delivered at the sessions.

An exhibition of electronic apparatus for physical research was opened in the building where the conference was held, and contained a new constructions of multi-channel amplitude and time analyzers, single-channel descriminators, instruments for the measurement and registration of radiation, photoelectronic multipliers, scintillators, many stands with elements and units of electronic apparatus, etc. The latest number of exhibits at the show were exhibited by the Institute of atomic energy.

Operating at the conference were the following sections: detectors of nuclear radiation, amplitude and time analyzers, automation of measurements and data reduction, pulse apparatus, and amplifiers and stabilizers for direct currents and voltages.

At the sessions of the detector sections for nuclear radiation (chairman, V. K. Voytovetskiy) the largest number of papers was devoted to scintillation methods. In an interesting communication, A. G. Berkovskiy considered new types of time photoelectronic multipliers with good characteristics. The characteristics of modern photoelectronic multipliers were examined in detail in many papers. It follows from these communications that only individual types of photomultipliers can operate under conditions of strong cooling and under heavy loads. Unfortunately, the types of photomultipliers produced by the industry do not satisfy these requirements. Many lecturers emphasized the need of a most rapid commercial availability of photomultipliers based on the construction of N. S. Khlebnkov and G. S. Vil'dgrube.

For further improvement of the scintillation method, the question of stability of the characteristics of the photomultipliers

is of importance. Data on the stability of the photomultiplier gain, as obtained by the organizations that manufacture the multiplier, do not agree with the data of the scientific research institutes. It is therefore conceded to be necessary to have the investigations of the parameters of the photomultipliers carried out by a joint commission.

Valuable results of an all-out and deep study of plastic scintillators were given in the paper by Ye. Ye. Baroni, N. A. Bartanov and others, presented by the Physics Institute of the Academy of Sciences Georgian SSR. An interesting paper on a scintilation counter with liquid xenon was delivered by N. D. Galanina and B. F. Shvartsman. Worthy of high praise are the Cherenkov total-absorption gamma spectrometer considered in the paper by V. F. Grushin and others (Physics Institute, Academy of Sciences USSR) and also the Cherenkov counter for the registration of fast electrons (N. G. Afanas'yev and others).

Several papers and communications devoted to non-scintillation methods, were delivered at the conference. These papers included: a paper on a low-voltage halogen counter, a paper on the choice of optimum conditions of operations for semiconductor counters, etc. A very interesting paper was delivered by O. A. Myazdrikov on the possibility of counting neutrons with an electret.

Most of the papers delivered at the section of amplitude and time analyzers (chairman N. V. Shtranikh and L. A. Matalin-Slutskiy) were devoted to complex systems. Unfortunately, a considerable portion of the reported material was accessible only to a narrow circle of specialists working in this field. This was due to the fact that owing to the shortage of time the material was delivered very briefly, without explaining the general principles.

At the first session there were considered the most complex multichannel systems, in which ferrite memory devices were used. These investigations were performed on a high scientific level. Two papers were devoted to individuals analyzer units intended for amplitude-time conversion (paper by A. A. Sanin and by G. P. Mel'nikov). The material discussed in these papers is of interest, since these principles make it possible to reduce substantially the resolution of amplitude analyzers.

In the nearest future, apparently, extensive use will be made of analyzers for plotting multi-dimensional spectra. A paper on such a set-up for universal use was made by A. A. Markov. I. V. Shtranikh delivered a paper reporting on an improved construction on a 20-channel multi-dimensional analyzer. An interesting paper on a project of a multi-dimensional analyzer having 16,000 channels, was made by A. M. Shimanskiy, A. A. Ivanov, L. A. Matalan-Slutskiy, and others. To solve many problems in nuclear physics, a general-purpose digital measuring system (MTsIS) is being readied for regular production. Several papers were delivered on this

complicated and interesting system by A. S. Kuruchkin, I. S. Krasheninnikov, Sh. I. Barilko, etc. Individual units of this setup were displayed at the exhibit.

A very urgent problem is the production of a relatively simple, cheap, and not too bulky amplitude analyzer. Such an instrument would find very wide application in laboratory practice. In this connection undoubted interest attaches to the paper on the amplitude analyzer with magnetic drum (M. V. Pasechnik, R. G. Ofengenden, and others). Analyzers with magnetic drums are most reliable, and it is therefore desirable that such instruments be produced by the industry. From the point of view of simplicity, and consequently also reliability, a competing system is an analyzer using ferrites with sequential insertion of the data in the matrix. A paper on such a new system was delivered by Sh. I. Barilko. Several papers were devoted to amplitude analyzers, in which the memory device used are potential scopes (ELA-3 and AMA-3). Such analyzers have found extensive use in the Soviet Union. An interesting communication on the modernization of the AMA-3 was delivered by V. O. Vyazemskiy.

At the present time semiconductor elements are finding an increasing application in electronic apparatus. As a result of their compactness and economy, such elements should almost completely replace vacuum tubes in the nearest future. Particularly interesting in this connection is the paper by V. B. Chernyayev and others on a time selector, made up almost completely of semiconductor elements. The absence of a sufficient assortment of semiconductor elements in the laboratory makes their extensive use difficult.

In the concluding section of this section communications were heard on analyzers in the multimicrosecond range (A. A. Kurashev, A. F. Linev, and others). This branch of radioelectronics, being the most complicated and specific, was represented by a relatively small number of papers. More rapid development in this is delayed by the lack of a sufficient number of generators, oscillographs, and other apparatus for millimicrosecond range in the scientific research institutes.

The work of the section of the automatization of measurements and data reduction (chairman B. N. Moyseyev) was related to the work of section on amplitude and time analyzers. Most communications were devoted to various constructions of number-printing devices for multi-channels systems. A lively discussion was caused by papers by G. P. Mel-nikov on a printer for multi-channel analyzers, by S. N. Salov on a printer for information output from the MTsIS. At this section there were also discussed problems in mathematical processing of results of measurements of difference spectra with allowance for the dead time of the spectrograph. An interesting paper on a semi-automatic method of processing bubble-chamber photographs was delivered by V. S. Kaftanov, L. L. Likhtenbaum, and others.

The section of pulse apparatus (chairman A. A. Sanin considered methods of amplification and generation of signals and also various apparatus intended for oscillography, counting, and measurement of amplitudes of voltage pulses. A new method of relative measurements was explained in the paper by Ye. I. Agishev and V. B. Chernyayev. This method makes it possible to use one system of amplification for two detectors and the ratio of the pulse amplitudes is practically independent of the fluctuations of the power supply voltages. A communication by A. A. Sanin, Chang Wang-chu, and Ch'u Ch'iang-shih on high-stability and non-overloading amplifier has caused a discussion. As a result of the discussion it became clear that at the present time there is no clear-cut definition of the overload coefficient of amplifying devices, which makes it very difficult to compare various systems.

In a paper by A. I. Veretennikov and others, methods were discussed of application of vacuum tubes under overdriven conditions for amplification of short pulses. The result obtained by the authors are undoubtedly of interest; however, the authors of the paper did not investigate the change in the service life of the tube.

A paper by V. M. Gorbachev, I. A. Uvarov and L. D. Usenko was devoted to a faster type pulsed oscillograph which has practically no dead time. An interesting communication on new oscillographs being readied for new production was presented by V. M. Levin. These oscillographs have the following characteristics: U.0-1-M -- amplifier band width 0-25 Mcs, sweep frate from 0.025 to 10 microsecond/cm; DEO-1 -- amplifier bandwidth 0 -- 20 Mcs, sweep rate 0.05 microsecond/centimeter to 2.5 microsecond centimeter; PSO-1 -- amplifier bandwidth 5 Kcs -- 200 Mcs, sweep rate from 2.5 millimicrosecond [centimeter to 20 microsecond] centimeter. It would be desirable to have these laboratory instruments placed in production by the industry in the shortest possible time.

Several communications were delivered on methods of limitation of short pulses. E. Ye. Berlovich and others reported a method of amplitude limitation of voltage pulses based on the use of junction silicon diodes. Another method, proposed by G. N. Sofiyev and N. A. Ukhin, is based on the use of ordinary vacuum tubes. This method of amplitude limitations is applicable for pulses of sufficiently large amplitudes. In an interesting paper, A. A. Vorob'yev and others considered a method of measuring voltage amplitude pulses with accuracy to $\pm$0.01 percent. The measurement of pulse amplitudes in the millimicrosecond range is a rather difficult problem. A. N. Gryaznov has constructed a compensation voltmeter with which it became possible to measure pulse amplitudes of duration of one millimicrosecond with accuracy of one percent. A communication of methods of generating voltage pulses in the millimicrosecond

range was presented by A. A. Tyul'nikov. He listed the existing generators for the millimocrosecond range T. GKI-1 with a minumum duration of output signal of 10 millicroseconds GKI-5 -- 5 millimicroseconds, and GKI-4 -- 1 millimirsecond. The most promising direction in further shortening of pulses is an improvement of the existing mercury relays and also the use of shock waves. I. G. Katayev lectured on the theoretical foundations of the latter method of shortening voltage pulses. Several communications were devoted to scalers using semiconductor elements. V. I. Kadashevich reported on methods of visual indication of the states of scaler cells based on transistors. Of particular interest was raised a promising method of interpolation, based on the application of luminophors. In another paper (K. F. Kuznetsov) there were considered methods of indicating the states of scaler cells, based on the use of relaxation circuits. Concerning the new types of Russian dekatrons, a report was made by I. Ya. Breydo. The assortment of dekatrons produced by the industry has considerably increased. At the present time production has been organized of new signal-pulse dekatrons OG-3 with limiting counting rate of 20,000 pulses. It would be desirable for the industry also to produce commutator dekatrons.

The work of the section on amplifiers and DC voltage stabilizers and current stabilizers (chairman K. E. Erglis) begin with a content full paper by L. B. Ustinova. The author related in detail on an electrometric amplifier, constructed on the basis of new rod-type lamps. This amplifier has a simpleconstruction and better characteristic compared with the EMU-s which is produced by the industry.

The majority of other papers delivered at this section were devoted to methods of stabilization of power-supply voltages. N. A. Ukhin delivered an interesting communication on the use of semiconductor elements in voltage stabilizers. A. A. Sanin and S. A. Sergeyev reported a circuit for power supply for radiation detectors with a stability of $\pm$0.01 percent. Many papers at this section were devoted to methods of measuring and stabilizing magnetic fields.

In the concluding section of the conference, the radiation stability of semiconductors was considered. A particularly lively moment was caused by the paper of L. N. Korablev on the use of cold thyratrons. It was noted that rapid progress in this new and interesting field is slowed down by the low quality of the cold thyratrons produced. In this connection it is necessary to review the existing technical specifications for these tubes.

The chairman of the organizing committee of the conference, A. A. Markov, listed in his concluding remarks the most urgent and promising trends in the field of nuclear radioelectronics. These trends include the following: methods of multidimensional measurements, amplitude and time analyzers for the millimicrosecond range,

high speed oscillographs (with a sweep of 10^{-8} sec.), reduction in the resolution time of the amplitude analyzers, electronic systems for data reduction, etc.

The conference made it possible to discuss new methods and promising trends and also to realize extensive exchange of opinion between specialists, leading scientific research organizations, and industrial enterprises, a fact which will contribute to further development of work in this field.

Chronicle of the Second All-Union Conference on Gas Electronics*

[This is a translation of an article written by V. L. Granovskiy, S. Ya. Luk'yanov, G. V. Spivak and I. G. Siromenko in Radiotekhnika i elektronika (Radio Engineering and Electronics), No 8, 1959, pages 1339-1358].

A conference called by the Academy of Sciences USSR, the Ministry of Higher Education USSR, and Moscow State University imeni V. M. Lomonosov was opened at Moscow State University by an introductory address by the chairman of the organizing committee, Academician M. A. Leontovich. Greetings from the Academy of Sciences USSR were delivered by the secretary of the Department of Physical-Mathematical Sciences, Academician L. A. Artsimovich, who noted the rapid growth in gas electronic and the rising interest in it in recent times in particular as related to work on the production of controllable thermonuclear reactions.

The dean of the physics faculty, V. S. Fursov, in greeting the conference in the name of Moscow State University, pointed to the increasing significance of processing gas plasma, in modern natural sciences.

Many survey papers were delivered at the plenary sessions.

L. A. Artsimovich reported on "Producing Superhigh Temperatures in Plasma." The lecturer explained the principal trends in works on production of super high temperatures both by heating the plasma through the work of compressing it, and by introducing into the plasma streams of high energy particles and taking steps towards preventing their leaving the plasma ("magnetic corks" and "magnetic traps"). The principal configuration of the gas volumes and magnetic fields used in this case were outlined, and the methods used for determining temperatures were indicated. Estimates of temperatures reached in various laboratories have been critically reviewed. The

* Compiled from the minutes of the sessions of the conference, presented by section chiefs.

lecturer takes the most probable temperature reached in apparatus with the toroidal tubes of the "Zeta" type as being 5 or 30 ev, that is, 300,000 degrees K (instead of the figure of 5 to 6 millions of degrees K found in the literature).

The increasing interest in gas plasma and in the new possible applications of the plasma necessitate a critical review of the developing notions and a search for new methods of its investigation.

A survey of optical methods of investigation was reported in the papers by V. A. Fabrikant and S. E. Frish. In the first of the papers there was emphasized the feature of investigations of emission characteristics as a measurement method that introduces no changes whatever in the phenomena that take place. Along with this, difficulties were noted in such measurements, caused in many cases by the lack of proven theory. Also considered was the method of luminescent probes, which makes it possible to investigate the volume distribution of the radiation of the gas; the absorption, which is very sensitive both to small concentration of absorbing particles and to extraneous influences (the form of the source line etc.); the Rozhdetsvenskiy interference method and, finally, the method of small admixtures. The advantages and shortcomings of these methods were estimated.

In the paper by S. E. Frish, in addition to these problems, there was considered the Rozhdestvenskiy hook method and a survey was given of the result of the measurement of the concentration of normal and excited atoms in a plasma and in the cathode regions, carried out at the Leningrad State University by optical methods. Comparison was made with the results of electrical measurements. The lecture gave rise to many questions.

S. Brown (Massachusetts Institute of Technology, USA) made a survey of high-frequency methods of investigating stationary and nonstationary (in particular, decaying) plasma, which make it possible to determine in the plasma of the concentration of the electrons the electron temperature, the collision frequency, and the effective cross sections of collisions of the electrons and ions with the molecules of the gas. The lecturer analyzed the limits of determination of these parameters from the shift of the resident frequency and from a direct observation of the phase shift and attenuation of the electromagnetic waves and indicated new methods; the use of the lowest frequencies (on the order of several megacycles) for the determination of large concentration of large particles; measurement of effective cross sections of collisions in a splasma placed in a magnetic field by plotting the resonance curve near the cyclotron frequency; measurement of the electron temperature by the plasma noise and its diamagnetism (see page 1233 [of source]).

Two survey papers were devoted to elementary processes and gases.

N. V. Federenko, in a paper "Ionization and Inelastic Scattering in Atomic Collisions" reported data on ionization, excitation and non-resonant charge exchange in impacts between ions and atoms, obtained to a considerable extent in the investigations of the Physical-Technical Institute, Academy of Sciences USSR.

Particular attention was paid to the production of multiplicharged ions by removing several electrons from the atom directly, something that takes place at ion or atom energies exceeding several kilovolts. The maximum yield of this process takes place at a linear ion velocity on the order of the orbital velocity of the electrons.*

In connection with this paper, O. B. Firsov made a brief theoretical communication on the kinetics of the process of ionic collisions.

L. A. Sena and Yu. M. Kagan presented a paper "Elementary Processes that Determine the Motion of Ions in their Own Gas. In monatomic gases the principal role is played by resonance charge exchange, the cross section of which can be determined by measuring the drift velocity of the ions by some method (for example, by the Doppler shift of the spectral lines). In molecular gases a considerable role can be played also by inelastic impacts which lead to the excitation of vitrational and rotational levels.

A joint paper "On the Role of Resonance Charge Exchange in the Kinetics of Ions" was delivered by Academician E. Bedereu (Rumania).

Three papers were devoted to processes of occurrence of spontaneous current in gases under various conditions.

I. S. Stekol'nikov reported on the initial stages of spark development. The entire process was subdivided into stages: corona, leader, principal channel, and final. In the corona stage, along with the well known shape of the nonstationary corona, which is explained by the cascade -- streamer mechanism, there exists another form, which occurs at field intensities of merely 1000 v/cm and propagates a velocity of 10^8 -- 10^9 cm/sec; its explanation calls for the introduction of different physical concepts. The lecturer dwelled also on the experimental data for the mechanism of different stages of the spark. In particular, it was noted that the technical (volt-second) characteristics of the insulation gaps are determined by the first two stages of spark development (corona and leader).

In a discussion following this paper, S. L. Mandel'shtam emphasized that in the final stage of a large spark current, the energy of the soruce is consumed essentionally in the production

*For the paper by N. V. Federenko see "Uspekhi fiz. Nauk" 1959, 68, 481.

of a shock wave in the gas; this circumstance can be taken as the definition of the final stage.

B. N. Klyar'fel'd gave a survey of the processes of discharge ignition in strongly verified gases. A characteristic feature under these conditions is the role of the cold emission of the electrons from the cathode, first in the form of glowing points (emission centers) and then, at currents on the order of a milliampere, in the form of a thin bright fillament. In order to explain the phenomena of ignition, in addition to the processes ordinarily considered (those of ionization and gas by electron impact and secondary emission of electrons under impact by positive ions) it is also necessary to take account of the reflection of the electrons from the anode, the ionization of the gas by impact of ions, and charge exchange of ions. Under certain conditions the ignition may lead to the establishment of a special form of stationary current, at which the voltage on the electrodes remains equal to the voltage remains equal to the striking voltage.,

The question of the mechanism of the breakdown of the high-vacuum gap was discussed in a paper by V. L. Granovskiy. The lecturer noted that there exists no single mechanism for all cases of the breakdown of such a gap. In the case of very gaps or thin pointed cathods the decisive processes are field emission and evaporation of one of the electrodes, the anode in the former case and the cathode in the latter. At larger gaps between electrode with the usual configurations, the decisive role may be played by mechanical action of the electric field which may cause deformation of the electrodes, an increase in the microscopic points on them, and the breaking away of the entire pieces, leading to a breakdown of the gap.

In the disucssions following this paper, S. Brown defended a different point of view, according to which the field emission in very high vacuum is the principal process of breakdown for any configuration of electrodes.

L. Tonks (USA) developed a theory of the motion of electrons in a "magnetic trap" of the type used in the "stellarator" (American experimental set-up for producing high temperature plasma) (see page 1316 [of source]). Academician R. Rompe (German Democratic Republic) reported on a set of investigations under his leadership on research in non stationary states of plasma. M. Stenbeck (German Democratic Republic) devoted his communication to generalization in the theory of plasma -- "the principle of minimum voltage."

Six sections participated in the conference.

In the first section (chairman L. S. Sena) papers were delivered on elementary processes in gas principally on phenomena that takes place in the collision of heavy particles.

In a paper "Transformation of Positive Ions into Negative

Ones in Rarefied Gases" Ya. M. Foget' considered the general laws of the process of two-electron charge exchange of a singly-charged positive ions. An analysis of the curves showing the dependance of the cross section of the process of the ion velocity shows that the succession of maxima on the curves satisfies the Massey abiabatic criterion.

In a second paper, written jointly by Ya. M. Fogel' and V. A. Avkudinov and D. V. Pilpenko, "Capture and Losses of Electrons upon Collision between Fast Carbon and Oxygen atoms with Gas Molecules" the lecturers reported data for the capture cross sections and the electron losses upon passage of carbon and oxygen atoms through helium, neon, argon, krypton, xenon, hydrogen, nitrogen, and oxygen. The observed dependence of the cross sections of these processes on the type of fast atom and target molecule, in particular the sequence of maxima on the curves showing the dependence of the cross section on the atom velocity, are considered, as in the preceeding paper, from the point of view of the Massey criterion.

The question of the conditions of applicability of the Massey criteria was the subject of a discussion at the sessions of the section. The participants in the discussions, N. V. Fedorenko, G. V. Drukarev, L. A. Sena and I. P. Flaks noted that the application of the Massey criteria is possible only for processes that take place at large distances, whereas in cases considered in the papers by Ya. M. Fogel' and his associates, a mutual penetration of the electron shells takes place. In addition, the Massey criterion itself should be considered not as a method of estimating cross sections but only as a criterion for the applicability of the semi-classical mathod analysis of the phenomenon.

The paper by N. V. Federenko, V. V. Afrosimov, and D. M. Kaminker "Dissociation of Molecular Ions of Hydrogen in Collisions in Gases" was devoted to the result of the measurements of the cross section of the production of protons during dissociation of molecular ions of hydrogen in collisions with molecules and atoms of gases (helium, argon, hydrogen, air). Measurements were carried out in the energy interval from 5 to 180 kev. The discussion of the paper concerned essentially the comparison of the result obtained by the lecturers with the result of Barten. A considerable discrepancy between these was explained by many methodical errors in the work of Barten and differences in the method of calculating the cross section.

In a paper "Capture Cross Section of Electrons by Multiply-Charged Ions in Inert Gases" I. P. Flaks and Ye. S. Solov'yev reported on the results of measurements of the cross section of capture of electrons by singly-charged, doubly-charged, and triply-charged ions of inert gases and the interval of accelerating voltages from 3 to 30 kv. In these processes it is possible for

different number of electrons to be captured, up to complete neutralization of the ion. In the latter case the charge exchange in the own gas has a resonant character. When resonance is violated it is observed that the cross section is much greater in the exothermal process than in the endothermal one.

R. M. Kushnir, B. M. Palykh and L. A. Sena, in a paper "Experimental Investigation of Resonant Charge Exchange in Certain Monatomic Gases and Vapors of Metals" gave measurement results on the dependence of the cross section of resonant charge exchange on the ion energy for argon, krypton, xenon, mercury, potassium and cesium in the interval from 6 to 990 ev. The relations obtained show that the cross sections diminish monotonically with increasing ion velocity. The dependence of the cross section of the ionization potential of the gas is found to be less steep than would follow from the approximate formula of L. A. Sena, and more steep than called for by the Demkov theory. The discussions of the paper dealt, on the one hand, with clarification of certain methodological problems (allowance for the reflection of the ions, allowance for the secondary electrons) and on the other hand with a comparison of the results of this investigation with data by others (Bydin and Bukhteyev) and with the theoretical conclusions of Firsov.

"A Qualitative Examination of Inelastic Collisions of Atoms" was the topic of a paper by O. B. Firsov, who started out with the assumption that the excitation of the colliding atom takes place as a result of electron exchange with transfer of momentum, which on the average equals the product of their mass by the collision velocity. According to the theory, the mean excitation energy increases with increasing atomic numbers, with decreasing impact parameter, and with increasing collision velocity. Without making use of arbitrary parameters, the author calculated the sum of the ionization cross sections, which coincides, accurate to a numerical factor on the order of two, with the experimental data within a range of a 20-fold variation of the collision speed.

Two papers at the sessions of this section were devoted to a determination of the excitation function; the paper by L. M. Volkova "Effective Cross Sections of Spectral Lines of Potassium and Argon" and a paper by I. P. Zapesochnyy and S. M. Kishko "Certain Results of Investigations of Optical Excitation Functions of Bands of Negative System." In the first of the papers results were reported on the measurement of the course of five arc and ten spark lines of potassium. The latter were compared with analogous arc lines of argon.

In addition to the foregoing communication, a paper was delivered by A. A. Vorob'yev and A. G. Vlasov, "Investigation of Electron Scattering in a Betatron Chamber," containing a report of preliminary experiments, connected with the development of the

measurement procedure.

The second section (chairman B. N. Klyarfel'd) of the conference was devoted to studies of electric breakdown in rarefied gases and high vacuum.

In a paper by G. Ye. Makar-Limanov and Yu. A. Metlitskiy "Electrostatic Control of Ignition of the Glow-discharge Tubes," results were reported on the investigation of electrostatic control of the ignition of glow-discharge with the aid of electric fields applied to the auxiliary electrodes (see page 1274 [of source]).

It was reported in a paper by S. V. Ptitsyn, D. D. Aleksandrov, and N. F. Olendzkaya on the investigation of the character of breakdown in a high-voltage tube with mercury cathode, that at low pressures the electric strength is limited by the vacuum breakdown. At higher pressures of gases, the left branches of the Paschen curves were plotted for a single-gap tube at voltages up to 300 kv. These measurements showed agreement with the data published in the literature. Also investigated were the role of the supplementary electrodes with "floating" potentials placed between the main electrodes (see page 1278 [of source]).

M. Stenbeck noted that the strength of a discharge cap can be increased by using conic grids, which act as an electrical lens.

In a paper "Ignition of a Discharge in Inhomogeneous Fields at Low Gas Pressures" L. G. Guseva reported on the ignition of a discharge on the conditions of the left branch of the Paschen curve, occuring in inhomogeneous fields of various configurations. The observed strong influence of the polarity of the electrodes is explained by the influence of the shape of the trajectories of the electrons and the ions. When the polarity is reversed the trajectories of the ions change differently than the trajectory of the electrons, owing to the charge-exchange process, which has a large effective cross section. This changes the paths along which the spontaneous discharge can be maintained, and influences the ignition voltage (see page 1260 [of source]).

A communication by A. S. Soboleva and B. N. Klyarfel'd "Curves of Discharge Phenomena Between Sharp Point and a Plane at a Gas Pressure of 10^{-5} to one milimeter mercury contains a description of an investigation of discharge phenomena in hydrogen between close electrodes; plane -- plane and point -- plane. In the case of a point cathode made of nickel and silver, the introduction of hydrogen caused a reduction in the currents; in the case of a tungsten point it caused a small increase. These results are explained by the change in the work function under the influence of the bombardment of a cathode by hydrogen ions. Observations under the microscope have shown the presence of light spots on the cathode and on the anode. These light spots were opposite each other and their spectrum contained the lines of the filling gas. In the case

of a point cathode it became possible to plot the volt-ampere characteristics of the individual emission centers. A discharge in the form of an arc, developing from the emission centers, is characterized by a voltage drop of several kilovots and its radiation spectrum consists of lines of the anode material.

T. B. Fogel'son, in a paper "Methods of Reducing the Energy Consumed in breakdown Formation " reported on various methods of reducing the energy consumed in the development of the discharge in low-pressure devices that have a grid between the principal electrodes. The application of an electron-accelerating potential to the auxiliary electrode causes a reduction in power in the grid circuit. By changing the waveform of the current pulse it is possible to reduce by several times the power consumed in the main discharge gap.

The following five papers concerned breakdown phenomena in high vacuum.

L. I. Pivovar and V. I. Gordienko, in a paper "Micro-discharges and Charge Exchange Between Metallic Electrodes and High Vacuum" reported on an investigation, performed with the aid of a transverse magnetic field, of the influence of the electronic current component on the production and development of micro-discharges in high vacuum. The observations have shown that the application of a magnetic field does not change the threshold voltage of the microdischarges. The magnitude of the charge transferred between electrodes, however, decreased in this case by a factor of 4 or 5. This indicates that the occurrence of micro-discharges is due apparently to heavy particles.

V. A. Simonov and G. P. Katukov, in a paper "Investigation of Processes of Initiation and Development of High-voltage Breakdown in Vacuum," investigated the development of breakdown, in the absense of dialectric walls, at voltages of 100-250 kv. Working with a pulse prob e procedure, high speed photography, and a mass-spectroscopic analysis of the ion composition, the authors have found that in the breakdown the gap is not filled with gas and the breakdown is not caused by the tearing away of the particles from the electrodes. It is found that as the plasma propogates from a local source on the cathode, the electrons and positive ions move with equal velocities, of 1 or 2 x 10^7 cm/sec. A hypothesis is advanced that the occurrence of the breakdown is caused by the presence of nonmetallic microscopic poles on the cathode, which are charged by the field emission currents.

A. S. Zingerman called attention to the fact that the hypothesis of the authors is only indirectly original and is similar to hypotheses previously expressed.

Ya. M. Fogel' noted that if the hypothesis regarding the role of local plasma sources is true, then there exists a practical method of increasing the electric strength by depositing

high purity metals on the gap electrodes.

In the work of E. M. Reykhrudel' and G. V. Smirnitskaya "Pecularities of Ignition in High Vacuum (10^{-6}-10^{-8} mm. mercury) in a Magnetic Field," it is stated that the observed delay of ignition is not a statistical delay and that it also differs from the discharge-formation time. Individual emission conters are produced on the cathode; the gases liberated from these centers lead to a general increase in pressure and to gap breakdown.

L. V. T rasova, A. A. Razin, and V. G. Kalinin reported on a transfer of electrode material in the pre-breakdown phase in vacuum, observed by the method of tagged atoms, and on the pulse coefficient of vacuum gaps. It was observed that the transfer is by charged particles of the electrode material. Motion picture microphotographs (the film was demonstrated) of the surfaces of the electrodes in the vacuum made possible the observation of the variation of the surface relief under the action of high voltage. The vanishing of the point (break-away) is accompanied by a breakdown of the vacuum gap. A hypothesis is advanced that the metallic points increase and break away from the surface of the electrodes under the action of constant electric field of 10^5-10^6 v/cm. The pulse coefficient of a two-electrode vacuum system was also investigated for short pulses (up to 5×10^{-8} seconds). The lecturers believe that the hypothesis that the charged particles break away from the electrodes is inadequate to explain the electrical breakdown at short pulses.

In a communication "On the Flight of Microscopic Particles of Matter in Electric Breakdown in Vacuum," N. B. Rozanova, M. V. Kozlova, and V. L. Granovskiy reported on observation of glowing tracks in a vacuum gap during breakdown. Experiments carried out on gaps up to one millimeter long with graphite or tungsten electrodes at voltages from 52 to 100 kv have established that the greater part of these tracks is the result of the flight of incandescent pieces of matter, broken away from electrodes. The charge of these particles -- on the order of several units CGSE -- is always positive. It is the result of the loss of electrons of the incandescent particle in flight (see page 1267 [of source]).

In a general discussion on the last five papers, Ya. M. Fogel' noted that the effect of the total voltage does undoubtedly exist. All the reported experiments have been carried out under imperfect conditions, and it is therefore difficult to generalize the results. But it is possible to carry out experiments that would decide which of the following is correct; the Krenberg hypothesis, the McKibben and Beyer hypothesis (development of chain reaction), or the Simonov hypothesis (local plasma sources)? For example, the second mechanism can be discarded if experiments

are so carried out as to eliminate the knockout of negative ions. If the idea concerning the influence of foreign inclusions is really correct, it would be advantageous to set up an experiment in which the electrode is covered with a metal known to be pure. The Krenberg hypothesis can be verified by etching the electrode by ion bombardment. A further development of experiments that could uncover the mechanism at long gaps is necessary.

L. A. Sena indicated that certain premises advanced by V. A. Simonov, touching on the displacement of the breakdown point on the unheated portions of the cathode for the adone, are subject to discussion. A more probable mechanism for the breakdown due to the occurrence of a strong field on the boundary between a film of dielectric and metal. The plasma can propagate to the anode with great velocity. The electrons escape, a positive space charge is formed, and this in turn chases the ions.

V. L. Granovskiy indicated that if potential distribution is as drawn by V. A. Simonov, the course of the curve makes it possible to estimate the sign of the space charge. It is doubtful whether a space charge of sufficient magnitude can appear at 10^5 v/cm.

V. A. Tsukerman noted that it is possible to conclude that there is no universal mechanism for vacuum breakdown. It is obvious that the mechanism of small pieces exists and that the experiments of V. A. Simonov are not convincing. The statement by Simonov that the material of the anode does not play any role is also incorrect. It is obvious that the gradient on the anode does play an important role in the course of the succeeding processes. Unfortunately, no work was done on the influence of dialectric walls on the vacuum breakdown. V. A. Simonov considers that with the aid of high speed photography he established that the particles leave the electrode within 50 microseconds after the breakdown, after the current stops flowing. To observe Krenberg particles, experiments were made to identify the electrode with which the particle collides and how the discharge develops. It was found that under our conditions discharge was not initiated by the flight of particle.

V. L. Granovskiy assumes that in different cases there may exist different breakdown mechanisms. The Krenberg mechanism is probable for relatively prolonged voltages. At short pulses it does not have a chance to operate and those phenomena which do not play a role at longer voltages come into the foreground.

The third section (chairman I. S. Stekol'nikov) was devoted to the electric sparks and corona and to their practical application.

A paper by V. I. Levitov, A. G. Lyapin, and V. I. Popkov "Probe Investigations of the Field of an AC Corona" contained material on the development and theoretical and experimental verification of the probe procedure for the investigation of

time-variable electric fields in the presence of a space charge. The authors of the paper formulate a procedure for probe measurements, and describe constructions of different probes together with the electric measurement circuits. The experimental research data are given together with their analysis. The physical criteria adapted for the simulation of the investigated field are justified theoretically.

In a communication by G. N. Aleksandrov "Elementary Processes in the Ionization Zone of Wires Surrounded by Corona at Atmospheric Pressure" there is given a theoretical and experimental justification for the processes around the discharging wire at different electrode polarities. The identity of the elementary processes in unipolar and bipolar corona is proved. The method of determining the initial and the critical voltages of the corona is justified.

V. A. Burmakin, in a paper "Occurrence of a Corona Discharge in Hydrogen and Nitrogen" reported that to develop special high voltage stabilizers of corona discharge he investigated the parometers of the corona field of a gas-filled interelectrode space.

In the discussions N. B. Bogdanova noted that it is necessary to engage in an investigation of inhomogeneities of the corona along its length; I. S. Stekol'nikov reported on the phenomenon of pulsed corona and stated that its elements are identical with those of AC corona. The lecturer G. N. Aleksandrov indicated that for his calculations it is not important what occurs afterwards -- a discharge, a cascade, a streamer, etc. These determine only the starting point. The calculations, on the other hand, contain mean statistical values. V. I. Levitov called attention to the fact that pulse and stationary coronas cannot be compared. The similarity occurs only in the elementary processes.

In a communication by P. N. Chistyakov, V. G. Gubanov, and Y. A. Burmakin "Certain Properties of Corona Discharge in Hydrogen Produced in a Coaxial Cylindrical System of Electrodes" there is a description of the volt-ampere characteristics of the corona discharge in hydrogen as a function of the pressure of the gas and the radii of the electrodes. A hysteresis was observed in the transient characteristics on going form the corona discharge into a glow discharge. The dependence of the corona ignition on the temperature of the surrounding medium is given.

A paper by A. S. Soboleva "Occurrence of Discharge Phenomena Between a Point and a Plane at Gas Pressures of 10^{-3} -- 1 Mercury" reports results of research on discharge phenomena near sharp points in the presense of hydrogen and inert gases, at the different pressures. A critical analysis of the data obtained is given. It is shown in the paper that the characteristics of

the currents have much in common for either polarity of the point.

A paper by Ya. Yu. Reynet, Kh. F. Tammet, and L. O. Val't, "Methods of Unipolar Ionization of Air by Aeroionizers," contains a simple method of obtaining unipolarly charged aerosols with the aid of an electric field and a special construction for a sufficiently low ionizer source voltage. The apparatus and the method which make it possible to inhale ionized oxygen or inject it subcutaneously are analyzed (see page 1335 [of source]).

M. P. Vanyukov, A. A. Mak, and V. R. Muratov, in a paper "Time Spectra of Radiation from a Spark Discharge in Inert Gases," have reported on the development of photoelectric spectrophotometric apparatus with time resolution of 5×10^{-8} seconds, permitting the tracing of the dynamics of the time variation of spectral lines in wavelength region from 2500 to 12,000Å. This apparatus has made it possible to establish that in the earlier stage of a high-temperature spark discharge in the atmosphere of inert gases there occurs a considerable concentration of doubly ionized gas atoms. It is shown that the absorption coefficient of the plasma is different for different portions of the spectrum (page 1284 [of source]).

In another paper, "Production of High Temperatures with the Aid of a Spark Discharge," M. P. Vanyukov and A. A. Mak report research on the spectral distribution of the intensity of radiation of a spark discharge produced in heavy inert gases, in a liquid capillary. The possibilities of using the developed capillary device as a comparison source in a measurement of high temperature is discussed.

The paper by V. A. Peretyagin "Influence of Magnetic Field on an Electric Discharge Along the Boundary Surface Between Two Media" contained a discussion of processes of development of a gliding discharge over the separation boundary between two media in the presence of a magnetic field, the direction of which is either the same as that of the electric field or perpendicular to the latter. An analysis of the experimental data obtained is given.

The communication by I. S. Stekol'nikov "Certain New Results in the Investigation of a Long Spark" contained the description of the results obtained with the aid of high speed electronic oscillographs, multi-cell electron optical shutters, electron-optical converters, and probes; the gradients in the leader channel were measured, and a dependence was established between the variation of the gradients with time and over the gap between a point and a plane. A quantitative relation was established between the volt-second characteristics of the insulation and the parameters of the pulse voltage generator. A procedure is proposed for selecting a comparison criterion for the volt-second characteristics.

The paper by M. I. Sysoyev "Features of Breakdown in Compressed Air in a Relatively Homogeneous Field in the Presence of Local Imhomgeneities in the Latter" describes experimental

research at commercial-frequency voltages and standard pulses, which has made it possible to establish the dependence of the breakdown voltage on the pressure. The paper contains data that explain certain features of a compressed-air discharge in an unusually inhomogeneous field. The data obtained are discussed critically.

The communication by A. A. Vorob'yev, G. A. Vorob'yev and K..K. Sonchik "Pulse and Oscillographic Techniques for Measuring the Delay of a Discharge in Dielectrics pertained to the development of circuits for producing rectangular voltage pulses with amplitudes up to 30 kv, and contains a description of a new oscillographic technique (see page 1257 [of source]).

The paper by B. N. Zolotykh on the topic "Principal Problems of the Theory of Electric Erosion in Pulsed Discharge in a Liquid Dialectric Medium" dealt with the theory of electric erosion for the media most frequently encountered in practice. The question of simulation of the investigated phenomena is considered. A procedure and apparatus are described for an experimental investigation of electric erosion (see page 1330 [of source]).

A lively discussion developed after this paper. A. S. Zingerman indicated that he doubted the validity of employihg the Stefan law in this case. The surface temperature of the metal was not constant. It is impossible to determine from the theory developed by the author, the volume of the scattered metal, since the cross section area of the scattered volume of metal is not indicated, and it is therefore impossible to compare the theoretical calculations with the experimental data.

It was noted in the discussions that such an approach to the problem can still be used, and the problem of the mechanism of erosion and the Stefan problem were also disuussed. Is the metal actually removed under the influence of ponderomotive forces? No, since an influx from the electrode metal is observed on the edges of the crater. The author is correct in stating that the erosion processes start with evaporation. The final stage is that of separation of large spheres. We compare the liberated amount of heat with the heat necessary to evaporate the metal. The latter amounts to approximately 10 percent of the former. The measurements are calorimetric. It can be concluded that in the case of refractory metals the metal is removed in vapor form and in the case of a low-melting-point metal it is removed in the liquid phase.

K. Ya. Senatorov noted that A. S. Zingerman opposed the theoretical premises of B. N. Zolotykh, but did not state his own premises. The paper shows a qualitative agreement between theoretical and the experimental data. Senatorov believes that valuable data have been obtained and an attempt has been made at

theoretically generalizing certain experimental data. It was indicated in the discussion that there is no agreement between the formula obtained on the basis of the experiment itself. Experiment has shown that the heat is liberated after the pulse, but this does not follow from the formula.

E. M. Reykhrudel' noted that so far it is impossible to develop an erosion theory in pure form; one cannot therefore demand of B. N. Zolotykh a complete theory of the problem. In vacuum we have observed discharges between discs, and the metallic surfaces were deformed thereby. Apparently, in these places local heating of the electrode took place and facilitated the deformation. These processes are therefore close to those that prevailed in the experiments of B. N. Zolotykh. Reykhrudel' believes that B. N. Zolotykh has correctly employed x-rays, but shorter exposures were necessary.

I. S. Stekol'nikov indicated that the attempt by B. N. Zolotykh to create a theory should be welcome. It is first necessary to give a simple theory, and the second stage of the work is to be made more complicated, so as to obtain a better agreement.

In the conclusion of the discussion, B. N. Zolotykh indicated that the remark by A. S. Lingerman on the impossibility of employing the Stefan problem is not valid. It is possible to determine tentatively the volume of the crater.

A paper by V. P. Larionov and D. V. Razevig "Energy Characteristics of High-voltage Insulation under Pulses" contains the results of an experimental investigation of the energy consumed from a source in order to develop the leader stage of a discharge, for air gaps of different configurations. From the data obtained a procedure is developed on the choice of insulation for electrotechnical apparatus.

In the discussion following the article, I. S. Stekol'nikov noted that the two principal arguments of the paper duplicate premises which are already known from the literature. The third argument, that the energy characteristics may serve as a convenient and reliable base for the choice of insulation, thereby eliminating difficulties connected with the volt-second characteristics, has been formulated thus far without foundation. Even if the authors have obtained all the necessary energy characteristics, it is still not clear what can be done with respect to coordination of the insulation. Nevertheless the investigation of the energy characteristics along with other characteristics of the leader are of interest.

I. G. Pulavskaya noted that the authors conclusions are interesting. The relation $W=f(t/\hat{p})$ was known earlier. The universality of the volt-second characteristic has been proved only for low-energy gaps.

The sessions of the fourth section (chairman S. Yu. Luk'yanov)

were devoted to a discussion of papers on nonstationary, low-frequency processes. The physics of pulse gas discharges at large currents and the properties of a high temperature plasma were included among these problems.

A paper by I. G. Nekrashevich and A. A. Labud "On the Problem of the Nature of the Current Pause in an Electric Explosion of a Metallic Wire," experiments were described on artificial blocking of the spark discharge in a narrow capillary by the vapor of the destroyed electrodes; a qualitative explanation of the nature of the current is given.

A communication by V. A. Simonov "Propagation of Plasma from Local Pulse Sources" contained the report of experimental research on the propogation of plasma from local sources in vacuum and in low-pressure gases in the absence and in the presence of an external magnetic field.

In the discussions following the paper, L. A. Artsimovich noted that the mechanism proposed by the author for the propogation of a plasma is very interesting. However, to attribute the energy loss in electrodynamic compression of plasma in high powered discharges the secondary "cold" plasma falling from the walls of the discharge chamber is wrong. The energy losses are so large that they cannot be explained even by assuming that the plasma is not "magnetized" and that ordinary heat conduction takes place.

G. N. Harding (Britain) indicated that in the "Zeta" apparatus electric arcs, "unipolar arcs," were observed between the plasma and the walls. It is possible these arcs transfer considerable energy flux to the walls.

In comment by Gottlieb (USA) it was noted that in apparatus of the "Stellerator" type, in the USA, the discharge chambers were made both of glass and stainless steel. Spectroscopic investigations showed less contaminations when stainless steel chambers were used.

G. G. Timofeyeva, K. P. Ryumina, V. I. Savoskin, and V. L. Granovskiy delivered a paper "Observation of an Electrodynamically Compressed Arc with the Aid of an Electron-optical Converter." It is seen from photographs of the arc, taken with the aid of an electron-optical converter, that the compressed column of the arc exists both when $di/dt \gtrless 0$ and when $di/dt = 0$, as long as the current is sufficiently strong. The pitch of the helix that characterizes the bending of the arc column depends on the parameters of the discharge. The disintergration of the pinch effect with decreasing current begins in the places of highest gas density. The experimental data were compared with the theory of the instability of a homogeneous plasma.

M. S. Ioffe and Ye. Ye. Yushmanov delivered a paper "Investigation of the Radial Electric Field in an Ion Magnetron." In their work they measured the distribution of the radial electric

field in a magnetic trap with mirrors on the ends. The plasma in the trap was produced by ions from a plasma beam, accelerated by means of an electric field between the beam and the side walls. It was shown that owing to ionization of the residual gas the distribution of the field differs greatly from the field in vacuum with allowance for the space charge. Under certain conditions fluctuations of a frequency of several hundred kilocycles were observed in the space potential.

V. A. Belyayev and K. K. Romanovskiy reported on "Experiments of a System with Magnetic Stoppers with an Electronic Model." It was shown that the fast electrons carry out up to one thousand oscillations between stoppers, and their lifetime in the system is determined not by the conservation of the adiabatic invariant, but by the introaction with the residual gas and by loss at the source.

A. M. Andrianov, O. A. Bazilevskaya, and Yu. G. Prokhorov lectured "On the Distribution of Magnetic and Electric Fields in High-power Pulse Discharges." They investigated a discharge in gases at pressures from 0.01 to 1 mm. mercury at an initial rate of current buildup of approximately 2×10^{41} amp/sec. An analysis of the distribution of the fields with time shows that the column of current becomes rapidly compressed under the influence of the electromagnetic forces, and the velocities of the particles reach approximately 10^7 cm/sec. A plasma temperature on the order of a million degrees is obtained in the compressed state.

G. N. Harding (England) in his paper "Spectroscopic Determination of Plasma Temperature in Zeta" (see page 1326 [of source]) discussed methods for measuring electron and ion temperatures in the Zeta apparatus. The ion temperature, obtained by analysis of the Doppler contour of the line N IV 3479, amounts to several million degrees. The electron temperature was measured from the relative intensities of the nitrogen lines of different excitation multiplicities, and amounted to approximately 100,000 degrees. The probability of excitation of the corresponding lines was calculated with electronic computers.

The paper by Harding, which aroused great interest, was followed by a discussion. In particular, L. A. Artsimovich indicated that the time required to establish equilibrium between the electrons and the ions is on the order of 2×10^{-5} sec. If this is so, then the temperature of the electrons and the ions should be of the same order of magnitude; yet according to the data of the lecturer, the temperature of the electrons is one order of magnitude less. In addition, in view of the strong ionizability of the atoms, the spectral lines of which was used to measure the temperature, it may be found that the Holtzmark effect will be greater than is proposed by the author of the paper. It was noted in the discussion that the observation was carried out perpendicular to the axis of the apparatus. At this orientation, in the case of ordinary gas dis-

charges, one observes greater widths than in the case of longitudinal observations, and the discrepancy is approximately one order of magnitude. S. Yu. Luk'yanov indicated that a quadratic Stark effect should take place for the investigated lines, and one should therefore observe not only broadening, but also a shift of the lines. S. L. Mandel'shtam noted in his comment that the experimental measurement of the shift may turn out to be unfounded, since there are no normals here. The lecturer in his answers agreed with certain of the remarks and indicated that additional investigations are being carried out on many of the questions.

A paper by S. Yu. Luk'yanov and V. I. Sinitsyn was devoted to the spectroscopic investigation of the heated plasma. Measurements of the absolute intensity of the continuous spectrum that occurs at the instant of maximum compression of the plasma pinch during a pulse discharge has made it possible to determine the concentration of the charged particles in the pinch. The experimentally observed thirty- to forty-fold compression of the plasma is in agreement with the theory. Measurement of the half-width of the ion lines of the nitrogen impurity leads to ion temperature values of approximately 1.5×10^6 K.

In the discussion following the paper, S. L. Mandel'shtam indicated that all the measurements in other discharges show that under such concentrations of electrons the Stark effect is greater than that mentioned in the paper. It was indicated in the reply that the Stark effect on the N IV 3479 line, used for the measurements, did not play any role in these experiments, since the line broadening decreases with increasing pressure, rather than increase.

I. M. Podgornyy and M. K. Koval'skiy lectured on "New Data on X-raysnin Pulsed Discharges." The end-point energy of the hard x-rays accompanying the pulse discharges in hydrogen were measured. It was shown that the x-rays are produced in the slowing down of the electrons accelerated along the axis of the discharge chamber.*

In the same session, a communication was delivered by V. A. Khrabrov and M. M. Sulkovskaya, devoted to an investigation of the neutron radiation of high-intensity gas discharges in chambers with conducting walls. A nuclear emulsion was used to determine the spatial distribution of the sources of neutron radiation and its energy spectrum. It is shown that the principal fraction of the neutron radiation results from accerlerating processes and is localized near the anode.

N. A. Borzunov, D. V. Orlinskiy, and S. M. Osovets reported on an "Investigation of Gas Discharge in a Conical Chamber." The contraction of the plasma towards the axis of a conical discharge chamber under pulsed discharges is not simultaneous. As a result a

*At an initial voltage of 40 Kv on the discharge tube, the electron energy amounts to approximately 300 Kev.

gas-pressure gradient is produced along the chamber axis, and leads to the appearance of a rarefaction wave. This process to a certain degree is equivalent to the formation of a cumulative jet.

This was followed by a joint paper (S. M. Osovets, Yu. F. Nasedkin, Yu. F. Petrov, N. I. Shchedrin, and Ye. I. Pavlov) "The Plasma Loop in a Transverse Magnetic Field." The conditions for the equilibrium and stability of the plasma loop in a transverse magnetic field were considered and an experimental apparatus and methods of measuring the characteristic quantities were described. Experimental data were obtained on the lifetime of the plasma loop in an equilibrium orbit and on the process of its convergence to the center, and these were found to be in good agreement with the initial premises.

I. G. Kesayev lectured on the division of the cathode spot of an electric arc (see page 1289 [of source]). The process of spot devision in the presence of a magnetic field was investigated photographically.

In the discussion of the paper, L. A. Sena noted that the "reverse" motion of the spot in a magnetic field has been observed long ago, but there is still no explanation for this fact. The explanation connected with the separate displacement of the space charges of the electrons and the ions was objected to by A. E. Robson (England), since at those charge densities which prevail in the cathode spot, any displacement of the charges of one polarity should cause a tremendous field which would liquidate this displacement.

In a communication "New Theory of Cathode Spot" (see page 1295 [of source]), A. E. Robson indicated that in the presence of "extraneous" plasma in the discharge gap, even if the plasma is of low density, it is easy to maintain low-voltage arc between the electrodes. The cathode spot of such an arc is maintained as a result of a bombardment of the surface of the electrode by a stream of excited atoms.

The lecturer was asked the question of the manner with which the well known fact of the excitation of the spot by an electric field agrees with the proposed theory, which attributed the existence of the spot to the action by the escited atoms. A. E. Robson explained that the existence and occurrence of the spot are two different processes. The theory proposed explains only the existence of the spot, which occurs as a result of some other mechanism, for example, field emission. In subsequent discussions, I. G. Kesayev noted that if Frunge's data on the current density in the spot are assumed to be reliable ($j \simeq 2 \times 10^6 - 10^7$ amp/cm^2), then the field emission mechanism explains the possibility of existence of the spot. However both the Engel theory and the Robson theory permit explaining the existence of the spot in an arc of low current density.

In a paper "Positive Column of a Discharge in Hydrogen under Stationary and Pulse Loads," L. N. Breusova investigated the potential

gradients in a plasma for various pressures, diameters, and discharge currents in the tubes.

At the following session, a communication was delivered by I. G. Nekrashevich and A. A. Labud "On the Distribution of Current on the Surfaces of the Electrodes in an Electric Pulsed Discharge." The electrodes were made of a bunch of wires insulated from each other. The low voltage pulse discharge was produced through a previously formed cloud of metal vapor.

A paper by L. S. Eyg was devoted to the topic "Certain Features of Gas Discharge in Low-voltage Halogen Counters." The principal parameters of low-voltage counters were established, both in self-quenched and in non-self-quenched operation.

G. I. Glotova and V. L. Granovskiy delivered a paper on a "Comparison of Initial Velocities of Deionization of Hydrogen (H and D)." The course of the deionization process in either gas is different from exponential; the ratio of the time constanty of deionization in deuterium to that in hydrogen is 1.4, both in diffusion and in the recombination modes. An explanation is proposed for the observed phenomena.

In the discussion of this paper, A. V. Nedospasov noted that if the concentration of the ions is not homogeneous along the discharge axis (strata) then actual diffusion also begins when the discharge stops. This leads to a deviation from the well known exponential law.

L. A. Akol'zina reported on the pre-discharge pulses of current at reduced pressure. The critical voltages for the occurrence of pre-discharge pulses of current were measured as functions of the geometry of the tube, the pressure, and the type of gas.

In the discussion of the communication, A. V. Nedospasov indicated that the investigated processes connected with the problem of operation of fluorescent bulbs, and is therefore timely. He noted also that the condition of the external surface of the bulb influences greatly the processes that take place there and that according to other available experimental data the rise time of the pulse is two orders of magnitude greater than indicated in the present work.

The paper by M. Ya. Vasileva and A. A. Zaytsev was devoted to the topic "Waves of Space Charge Oscillations in a Cylindrical Plasma." The action of an external periodic force on the cathode region causes plasma oscillation waves to propagate from the cathode to the anode. The velocity is investigated as a function of the geometry and of the gas pressure.

In the next paper by A. A. Zaytsev and K. Efendiev, a report was made of the investigation of anode oscillations and a low pressure discharge. The region adjacent to the anode may become unstable. The experiments included measurements of the amplitude and of the frequency of oscillations in the anode portions of the plasma over the wide interval of pressures and intensities of the discharge current.

L. Pekarek (Czechoslovakia) reported on low-frequency wave-like phenomena in a glow discharge plasma. The author proposed a new mechanism to explain the formation of strata.

At the last session of the section, communications were delivered by V. G. Brezhnev on a mass-spectrometric investigation of the energy of fast ions in a pulsed discharge, by B. B. Kadomtsev "On the Convective Instability of a Plasma Pinch," by T. F. Volkov "On the Influence of the High-Frequency Field on the Plasma Vibrations," and by S. I. Braginskiy and V. D. Shafranov "On the Theory of the High-temperature Plasma Pinch." In the work by V. G. Brezhnev, the parabola of J. J. Thompson was used to determine the energy of the particles. The production of fast ions indicates the presence of accerlating processes in the pulse-discharge plasma. The ion energy reached 200 kev.

The communication by T. F. Volkov concerns hydrodynamic theory of plasma oscillations in the field of a traveling electromagnetic wave. It is shown that frequencies of acoustic and Langmuir oscillations become functions of the amplitudes of the high-frequency field. A possible mechanism is discussed for the occurrence of instabilities, when the wavelength of the disturbance is on the order of the electromagnetic wavelength.

B. B. Kadomtsev considered the stability of a plasma pinch with axial symmetry, maintained by the magnetic field of the current flowing along the pinch. Conditions are obtained for the stability of such a pinch both in the hydrodynamic approximation and with the aid of the kinetic analysis in the drift approximation.

A communication by S. I. Braginskiy and V. D. Shafranov was devoted to a theoretical examination of combined conditions of equilibrium, stability, and heating of a toroidal plasma pinch with longitudinal current and a strong external magnetic field. An expression is obtained for the ion temperature, which can be reached under the Joule mechanism of heating with simultaneous observation of conditions of pinch stability.

Phenomena in high frequency currents and gases were discussed at the fifth section of the conference (chairman, N. A. Kaptsov).

Y. Ye. Golant delivered a paper "Occurrence of Pulsed Microwave Discharges in Inert Gases," in which he considered starting with calculation of the distribution function for the electrons by velocities, and the determination of the critical intensity of the pulsed microwave discharges for xenon and kryton.

In a paper "Effect of Boundary Conditions on the Occurrence and Maintenance of a High-frequency Discharge'" G. I. Pateyuk reported on the measurement of the ignition potential and the maintenance potential of a discharge in a frequency range from 1.5×10^{-7} -- 3.0×10^{-8} cycles. In the discussions, Tonks and Galant noted the role of the conductivity and of the work function of the material of the walls of the discharge tube.

A paper by P. S. Bulkin, G. S. Solntsev and V. I. Ponomarev entitled "Investigation of Self-Maintaining Microwave Pulsed Discharge and the Process of its Establishment" reported on a procedure for investigating by means of electronic optical instruments the production of a microwave discharge. The technical details of the proposed procedure were taken up in the discussion.

A report by G. N. Zastenker and G. S. Solntsev entitled "Certain Results of the Investigation of the Production of High-Frequency Discharge at Low Pressure" presented a study of the behavior of a discharge current glow, and other parameters in the initial stages of a high-frequency discharge in argon.

A paper "Conductivity of Weakly Ionized Plasma" was delivered by G. Margenau (USA). It discussed the interaction between an electromagnetic wave and a plasma with allowance for inelastic collisions. S. D. Gvozdover, speaking after this lecture, proposed the formulation of a theory that takes boundary conditions into account. This would make it possible to employ this theory in the investigation of the operation of many instruments.

A. A. Kuzovnikov lectured on "Conditions of Changeover from a High-frequency Corona Discharge to a Flamed Discharge at Atmospheric Pressure," and reported observations on pulsed processes in a high-frequency corona and data on the frequency limit of changeover from flame to corona.

This was followed by a paper by O. F. Kibardin and K. F. Kuddu on a high-frequency discharge from a sharp point in air at atmospheric pressure.

The paper by V. Ye. Golant "On the Connection Between the Characteristics of Microwave Current and the Characteristics of Direct Current in a Gas" contained a description of the method of a direct-current analogy for the calculation of many characteristics of microwave discharges. The discussions dealt with a comparison between the theoretical and the experimental values of conductivity and the coefficient alpha.

A paper by B. B. Lagov'yev [Lagovier] treated the Conductivity of a decaying plasma on the window of a resonant discharge gap. The author succeeded in showing that the active component represents a small part of the total conductivity of the discharge, and that this ratio does not change during the entire post-discharge period.

During the course of the discussion, V. Ye. Golant commented that the concept of the additiveness of the conductivities of the window and of the discharge has not been proved. Consequently, the dependence of the conductivity of the discharge on the pressure, as represented here, may be due to an incorrect determination of the conductivity of the system. Furthermore, V. Ye. Golant called attention to the fact that as the speed of the de-electronization increases with increasing gas pressure the de-electronization acquired a three-dimensional character. This can be caused only by

the presence of electron-trapping impurities in the main gas.

A paper by S. M. Levitskiy and I. P. Shashurin was devoted to the applicability of the probe procedure to high-frequency discharges. The authors have measured the concentration of the electrons both by the probe method (signals and double probes) and by the microwave-resonator method. The results obtained by the single-probe method and by the resonator method were the same, but those obtained by the double-probe were ten or twenty percent higher. In a D. C. discharge, on the other hand, the double probe gives a concentration 1.5 or 2 times lower than a single probe (see page 1238 [of source]). Several serious critical remarks were made in the discussion of this paper.

Yu. M Kagan noted that it is incorrect to assume that the electron concentration has a Bessel distribution at low pressure, and indicated the need for employing the Langmuir theory in this case. He also raised doubts concerning the correctness of the accuracy in the measurement of the concentration of charges by the probe method, as determined in the paper. Yu. V. Gorokhov indicated that no account was taken in this work of the possible distortion of the resonator field by the glass of the discharge tube. V. Ye. Golant called attention to the incorrectness of using the Slater formula to determine the concentration of the electrons, in view of the fact that perturbation theory is not valid at high concentrations.

A paper by V. Ye. Mitsuk, N. D. Kuz'minykh, and I. V. Talalayeva was devoted to an investigation of microwave plasma with the aid of the Stark effect. The authors have calculated the contours of the lines of the Balmer series in the presence of a Stark effect in an alternating field. The fact that the half-width of the contour depends on the intensity of the electric field has made it possible to measure the amplitude of the microwave field in a discharge in hydrogen and deuterium along the axis of a rectangular waveguide.

A paper by G. S. Solntsev, A. G. Porokhin, and N. M. Chistyakova discussed electric fields in a high-frequency low-pressure discharge. The method of probing the discharge by means of an electron beam was used to measure both the high frequency field and the space-charge field. The results obtained also make it possible to determine the magnitude of the quasistationary space charge.

During the course of the discussion, Kornilov was interested in the variation of the electron beam energy as it passes through the plasma. The authors believe that the number of collisions on the diameter of the discharge column was quite small. S. M. Levitskiy noted that the integral of the field intensity over the length of the column should equal the voltage of the source. In the response, the authors indicated that these quantities differ by 20 percent, and that this may be due to the lack of measurements

of the field intensity near the surface of the electrodes themselves.

A paper "High-frequency Discharge in Methane" was read by E. Bedereu (Rumania). He noted that with the aid of discharge it is quite convenient to obtain acetylene and its polymers from methane. In the discussions, Bakanin and Taruze were interested in the high-frequency discharge mechanism. The author stated that this aspect is still unclear, and that the use of the high-frequency discharge was due to the desire of getting rid of internal electrodes.

At the same section, a paper was delivered by Ye. T. Kucherenko and A. G. Fedorus, devoted to the energy distribution of the ions extracted from a high-frequency gas-discharge source (see page 1233 [of source]).

The work of the sixth section (chairman, V. A. Fabrikant) was devoted to questions pertaining to plasma and methods of its investigations.

In the survey by Yu. M. Kagan "News in Probe Procedure for Plasma research" a method was given for determining the plasma parameters (concentration of particles, electron temperature, space potential) from the ionic and lower parts of the electronic probe characteristic. This procedure is applicable in many cases in which the Langmuir method cannot be used. Biberman and Panin, and also Johnson and Malter, have worked out a method using two or three probes, which dispenses with the need of a constant-potential point in the plasma. Many methods were proposed for improving the ordinary procedure, making it possible to duplicate probe characteristics on the oscillograph screen in a linear or semilogarithmic scale, under different discharge conditions.

The paper by V. I. Drozdov "Characteriographic Measurements in Plasma" was devoted to an automatization of the Langmuir probe method. An oscillogram is taken of the probe characteristic. The probe circuit is fed from a pulse generator. The sweep rate is 45-60 microseconds. The probe does not become incandescent even at large currents. In the investigation of a decaying plasma, the probe characteristic is plotted within several tens of identical periods.

In a communication by V. A. Simonov and A. G. Mileshkin "Investigation of the Motion of a Plasma with the Aid of a Mass Spectrometer during the Time of Flight" the described construction of three pulsed time-of-flight spectrometers intended for the analysis of ions that come out of a low-pressure plasma. The instruments make it possible to investigate plasma with a lifetime from 0.1 microsecond to 1 second.

The paper by A. V. Rubchinskiy "Use of Oscillations on a Small Anode for the Measurement of Vapor or Gas Density" describes a method of measuring vapor density, based on the use of dependence of the amplitude of the voltage oscillations, occuring on a small anode, on the vapor density (see page 1311 [of source]). In the

discussion, Yu. M Kagan noted that the measuring method may be considered reliable only when the physical nature of the phenomenon is clear.

A. A. Timofeyev, in a paper "Measurement of Gas Density under Dynamic Discharge Conditions," reported that use was made of the fact that the breakdown voltage and the voltage of occurence of spontaneous discharge on the positive probe, placed in a plasma of an intense discharge, depends on the vapor density or on the gas density (see page 1303 [of source]). In the discussions, many of those present expressed the opinion that although the method is of interest, it is necessary to clarify the extent to which the plasma is disturbed by such a probe.

S. M. Levitskiy and I. P. Shushurin (Measurement of Concentration of Charges in a Plasma by the Method of High-frequency Probe) reported on the possibility of measuring the concentration of charges in a plasma by introducing inside the plasma a probe connected to the microwave generator.

A. V. Nedospasov delivered a paper "Nature of the Striated Positive Column." Within the confines of a single striaton, the concentration of the charges changes by one order of magnitude. The striation consists of a double layer of charges and of a larger region -- the plasma. The solution is sought for the plasma region, and the head of the striation is not considered in detail. Formula are derived for the principal characteristics of the striation (velocity and length) as functions of a discharge parameters. A qualitative agreement is obtained between experiment and theory.

L. Pekarek (Czechoslovakia) noted in the discussion that he was not convinced that this work on the nature of striations solved the problem, since it did not result in periodicity, but merely started out with it. Only after explaining this very important linear phenomenon, which develops after a single pulse, is it possible and necessary to go to a consideration and explanation of the nonlinearities. The theory was also criticized by Chapnik, who indicated that the question of formation of striations was not solved. The proposed diffusion theory does not explain the following facts: 1) The Goldstein law, 2) in some gases there are striations and in others there are none, 3) in some gases the striations are damped and in others they are not, etc.

In a communication "Probe Theory for Arbitrary Pressures" V. I. Perel' and Yu. M. Kagan considered the theory of the electronic portion of the probe characteristic for the case when the collisions in the layer cannot be neglected. A spherical probe in considered; only elastic collisions between electrons and atoms are taken into account.

Yu. M. Kagan, V. M. Zakharova, and V. I. Perel' have reported on the "Positive Column of a Discharge in the Diffusion Mode." The authors have calculated numerically the transverse distribution of

the field, the concentration, and the temperature. Balance equations were obtained for the plasma along with an expression for the density of the ion current on the wall; the latter can be verified experimentally. The presence of a charged layer at the walls is taken into account. The distribution of the potential and concentration in the layer were obtained.

L. Tonks (USA) noted that analogous arguments were considered by him, too.

M. V. Konyukov established in his paper "Influence of Processes of Vanishing of Negative Ions on their Concentration in the Column" that the volume losses of negative ions are due to the collisions between the latter and the neutral atoms, and to volume recombination with positive ions. At sufficiently high concentration, the volume of the column is a source of negative ions, and at low concentrations it is a region where they vanish.

The communication by M. D. Gabovich and L. L. Pasechnik "Anomalous Scattering, Excitation of Plasma Oscillations, and Plasma Resonance" described the phenomena occuring when an electron beam from an extraneous source passes through a plasma. At a certain critical beam current, a strong interaction begins between the beam electrons and the plasma. The noise level in the plasma rises. The position of the zone of anomalous scattering is determined theoretically with sufficient accuracy. Values of the observed affect, which are of the correct order of magnitude, are obtained if one assumes that the principal role is played by coherent interaction between the electron bunches and the plasma. Plasma resonance is observed under conditions different from those described in the literature. A plasma generator has been developed.

Yu. L. Klimantovich, in the papers "Energy Lost by Charged Particles to Excitation of Oscillations in a Plasma" (On the Langmuir Paradox)" and "On the Theory of Nonlinear Plasma Oscillations," considered a system of beams -- plasma oscillations -- and found that there is a possible interaction mechanism, similar to the mechanism in the traveling wave tube. It is found that the phenomenon is described with sufficient accuracy by an equation that takes into account the production of the electron wave and the reaction of the wave to the electrons of the beam. By assuming that the velocity distribution of the electrons can be taken to be Maxwellian, and by adding to this distributor the electrons with non-zero directed velocities, it is possible to find the condition of self excitation.

Ye. G. Martinkov and I. G. Nekrashevich reported on the "Dependence of the Temperature in the Electrode Zone of a Pulsed Discharge on the Electrode Material." The authors report the results of an investigation by the Ornshteyn method of the temperature of a glowing cloud of condensed spark discharge near metallic electrodes. The use of mirror scanning has made it possible to establish

the time dependence of the temperature in the regions next to the electrodes.

N. A. Matveyeva and B. N. Klyarfel'd communicated "On the Formation of Light Spots on the Anode of a Gas Discharge." The spots occur at sufficiently large values of gas pressure and at a positive anode drop. The electron temperature inside the spot exceeds the electron temperature in the positive column by a factor of three times. The density of the discharge current at the spot is but slightly greater than the current density of the remaining anode. The intense ion beam from the spot to the anode region causes a reduction in the positive drop (see page 1301 [of source]).

N. A. Matveyeva reported "On the Separation Boundary Between Mixtures of Inert Gases in a D. C. Discharge."

The passage of direct current through a mixture of gases causes the mixture to separate. The gas which is lighter and is more difficult to ionize, becomes concentrated near the anode while the gas with the lower ionization potential is concentrated at the cathode.

V. G. Stepanova and V. F. Zakharchenko reported "On Certain Phenomena in a Rarefied Plasma." The behavior of a strongly rarefied plasma in a linearly decreasing magnetic field is considered. The initial particle velocity is found at which the particles are slowed down and give up their energy to the magnetic field. One can visualize a case in which the plasma, being under high presdure, expands adiabatically and the energy is effectively transferred to the magnetic field.

V. A. Fabrikant noted that at a large pressure this analysis is incorrect.

V. G. Stepanov and V. S. Bezel' reported "On the Possibility of Obtaining a Plasma of High Concentration."

The possibility of obtaining a plasma of high concentration with the aid of radioactive emitters is considered. The most suitable isotopes, with short half lives, are those which are pure beta emitters (Y-91).

G. V. Smirnitskaya and E. M. Reykhrudel' reported on "Certain Discharge Characteristics in an Ionic Pump and in a Magnetic Ionization Manometer." At large anode voltages the ionization occurs in a series of discharge zones. It was established by probe measurements that regions of space charge, which become rearranged as the pressure is varied are formed in the volume.

Ye. T. Kucherenko and O. K. Nazarenko communicated on "Features of a Discharge with Electron Oscillations in a Magnetic Field" and gave curves for the discharge current, the ion current, and the discharge potential drop as functions of the magnetic field. Pulsations of current are observed as the field is increased (see page 1253 [of source]).

L. M. Biberman and B. A. Veklenko considered in their paper approximate methods of determining the concentration of the

atoms at the radiating levels. An approximate method is proposed for taking into account the reabsorption of radiation by introducing the effective lifetime of the excited state, which depends on the coordinates. The concentration of the excited atoms is determined by an algebraic equation instead of an integral equation.

A communication was delivered by I. I. Sobel'man and L. A. Vaynshteyn on the "Nonstationary Theory of Stark Broadening of Spectral Lines in a Plasma."

The existing theory of impact broadening of spectral lines is based on the assumption that the collisions are quasi-classical and that the disturbances are adiabatic. This assumption suggest the possibility of neglecting the effects (quasi-static level shifts). These assumptions are not justified at all.

The theory proposed, which retains the quasi-classical analysis discards the premises connected with the interaction time.

M. A. Mazing and S. L. Mandel'shtan reported "On the Broadening and Shifting of Spectral Lines in a Gas-discharge Plasma."

The authors investigated the lines of singly ionized Ar II, in a highly ionized spark-discharge plasma in order to verify the theory of Stark broadening. Measurements yielded a radical qualitative disagreement with the theory.

The nonstationary theory of Vaynshteyn and Sobel'man, mentioned above, gives satisfactory agreement with the authors' data.

R. Lant (England) reported "On the Kinetics of Electron Collisions, which Lead to the Excitation of Molecular Hydrogen in a Hydrogen Discharge."

The author used the same method of examining the kinetics of a gas discharge is used by V. A. Fabrikant for discharge in mercury vapor.

The topics considered were ionization of the hydrogen molecule, excitation of the first and second electronic excited levels, and transitions from various levels with band production.

A theoretical curve was obtained at Oxford University for the cross section of ionization of the hydrogen molecule; the curve was found to be in good qualitative agreement with the experimental data.

V. N. Kolesnikov, V. N. Yegorov, and N. N. Sobolev reported on "Certain Features of Arc Discharge in an Atmosphere of Inert Gases." The question of the existence of thermal equilibrium in a weak-current discharge in inert gases was considered. The population of different levels was determined from the line intensities. It was found that the distribution of levels obeys an exponential law, which differs greatly from the Boltzmann distribution.

A. A. Mak and M. P. Vanyuka reported on "Production of High Temperatures with the Aid of a Spark Discharge." The highest temperature (up to 10^{-5} degrees) were obtained by producing a spark discharge in a liquid capillary.

To determine the temperature of various parts of the channel,

a simultaneous measurement was made of the intensity of the continuous and line radiation in the spectrum region from 2300 to 8500Å.

END